SR-02

Production Report

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Introduction.

SR-02 is a second Nb_3Sn subscale racetrack magnet builds at Fermilab using MJR conductor and wind and react technology (see Fig 1 and Table 1).
The goal for such a device is a testing of MJR cable in a magnet-like configuration.
Detailed description of all mentioned procedures listed in TD-04-007.

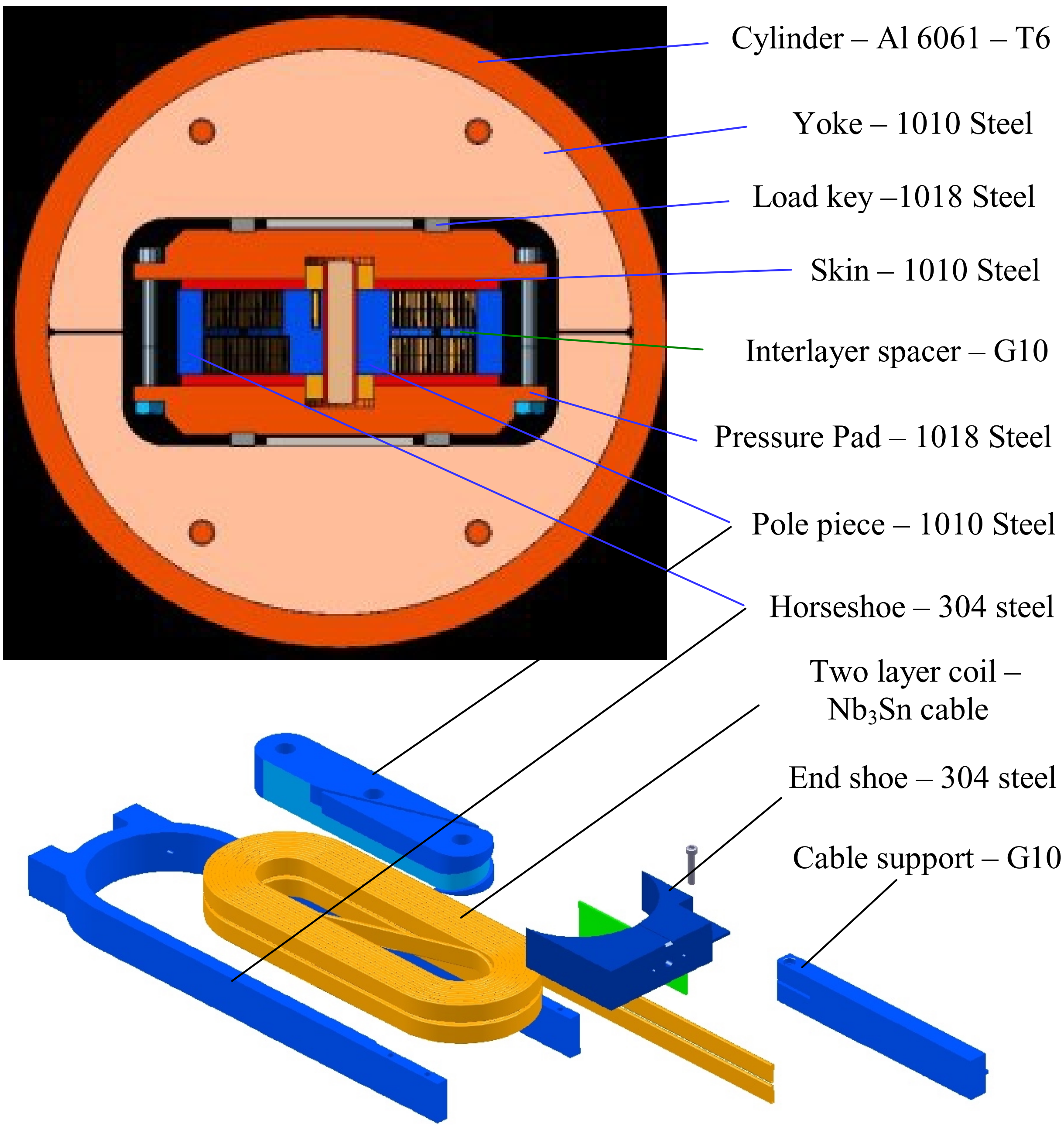


Figure 1. Small Racetrack Magnet

Table 1. Magnet and cable design parameters.

Magnet parameters	
B_{max}, T	11.06
I_{max}, kA	28.12
Aperture, mm	2
Coil area, cm^2	6.05
Number of turns per coil	13
Iron yoke OD, mm	215
Stored energy @ 11 T, kJ/m	19.05
Inductance @ 11 T, mH/m	0.05

Cable characteristics	
Material	Nb_3Sn MJR
Cable type	Rutherford
Dimensions, mm^2	13.85 x 1.95
Strand diameter, mm	1.0
Number of strands	28
Strand Jc (12 T 4.2 K)	2000
Cu/Non_Cu	0.85
Keystone angle	0

Cable Production and Test Data.

FNAL Cable Production and Test Facility produced and tested a cable for the coil using Nb_3Sn 1mm MJR strands. Strands and cable specifications are listed below.

CABLE No.	.
CHARACTERISTICS	1mm MJR - 28 strands
FINISHED	
OPERATOR	Tom Wokas

CABLE AND STRANDS LOG SHEET

- STRAND SPECS-

MANUFACTURER :	Oxford
PROCESS METHOD :	MJR
BILLET #:	210 214 218
COMPOSITION :	Nb_3Sn
NOMINAL STRAND DIAMETER :	1.0mm
NOMINAL COPPER CONTENT :	47.1%
NOMINAL RRR	-
FILAMENT DIAMETER-eff	110μm
FILAMENT PITCH AND DIRECTION:	13mm, right
RECOMMENDED HEAT TREATMENT	120 hr @ 650°C
I_c and N-VALUE @ 12T	$B_{\#}$ 210 832A 40 $B_{\#}$ 214 803A 35 $B_{\#}$ 218 810A 42

NOTES:

-FNAL STRAND DATA-

HEAT TREATMENT	25°C/hr to 660°C; 72 hr @ 660°C					
SHORT SAMPLE DATA OF WITNESS SAMPLES FOR SR-02						
BILLET & SAMPLE #:	**TYPE**	**I_c & N @12T**	**RRR**	**BARREL**	**DATE**	**BY**
218, 8A	VIRGIN	733A 40	70	TI	02-26-2004	B. BORDINI
218, 3B	VIRGIN	658A 38	-	SS	03-01-2004	B. BORDINI
218, 1	EXTRACTED	685A 35	-	TI	03-03-2004	B. BORDINI

NOTES:

-CABLING SPECIFICATIONS-

TYPE or SPEC.:	-						
REALIZED @	FNAL						
No. of STRANDS:	28						
PITCH DIRECTION:	left	**PITCH LENGTH:**	109.8 mm (nominal)				
PLANETARY RATIO:	1:1						
ROLLER ID #:	Original forming fixture	**WIDTH:**	Nominal	**ANGLE:**	0		
MANDREL ID #:	5525-MB-414004	**WIDTH:**	13.36mm	**THICKNESS:**	0.30mm		
LUBRICATION :	Oil G.P.						
STRAND TENSION:	4 pound	**TURKS HEAD LOAD "SGM":**					
Nom. THICKNESS:	1.84mm						
Nom. WIDTH:	14.2 +/- 0.1 mm						
Nom. ANGLE:	0						
CORE:	No	**MATERIAL:**	-	**THICKNESS:**	-	**WIDTH:**	-

-FINISHED CABLE-

FINISHED LENGTH:	
Avg. THICKNESS:	1.84
Avg. WIDTH:	14.20mm
Avg. ANGLE:	0
Cable/Strand Yield:	

RESIDUAL TWIST/Mtr.: ______________________

ETCH for FILAMENT DAMAGE: ______________________

NOTES :

Cable Preparation.

The Nb_3Sn cable was heat-treated at 200°C for 30 min (annealing process) to reduce the residual twist that comes from the cabling process.

Figure 2. Spool of cable is packed in Kapton bag for annealing.

Coil Size.

To obtain an acceptable coil dimension, size of bare and insulated cables were measured at different transfer pressure. Than a required reaction shim thickness was calculated base on insulated cable data at ~14MPa pressure and other parts dimensions.

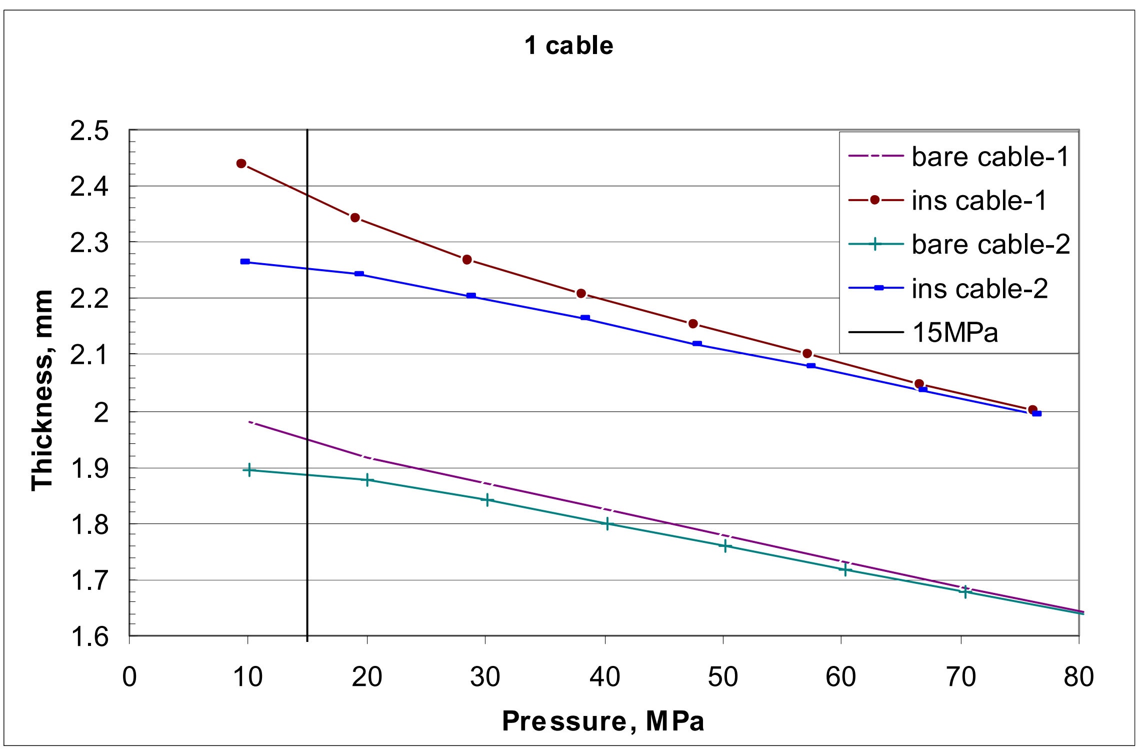


Figure 3. Result of two-cable stack measurements

Table 2. Coil Size Spreadsheet.

FNAL Coil Number — MJR uncompacted cable

Coil Package Components	Nominal Size in mm	Number of Components Turns	Total	Actual Size in mm
Insulated Conductor @ 2ksi equivalent	2.38	13	30.94	61.88
Mica Paper (Island only)	0.125	1	0.125	0.125
Island / Plasma Spray	37.2	1	37.2	37.2
Horseshoe Width	9.53	2	19.06	19.06
Total (Line 10 - 13)	49.235			118.265
Reaction Real Width	25.53	2	51.06	51.06
Coil With Horseshoe (15 + 17)				169.325
Plate	170.408	1	170.408	170.408
Glass Overhang	0	2	0	0
Effective Plate Size (22 + 23)				170.408
Difference (19 - 25)				1.083
Positive Number means large coil				
Shim Size mm / per side	169.325	+	Line26/2	0.5415
Shim Size inch / per side				**0.021319**
Shim Size is (1.895) or 0.075" Maximum!	If bigger try another turn			

Data
Calculation
Sum

Shim:	Sur dry tape	Sur dry tape	Mica		
	6.2	6.2	5	=	17.4 mil

Cable Insulation.

S-2 Fiberglass Tape 250μm × 12.95 mm has been used for Nb_3Sn cable insulation. The in-organic binder is first applied to a roll of insulation and then cured at 80°C for 30 min. This step improves the stiffness of the insulation. Than the cable was wrapped by a tape with ~3.3mm overlap using the insulating machine in IB3.

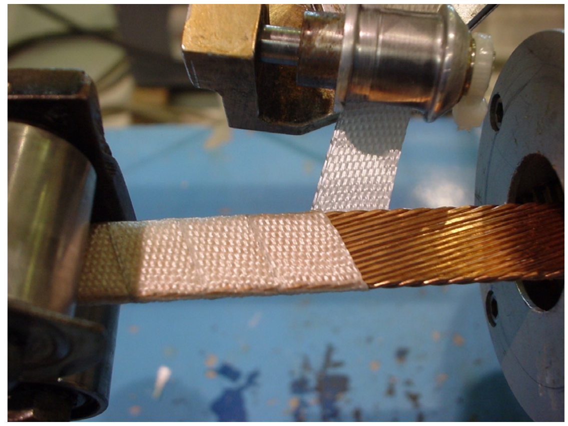


Figure 4. Cable insulation process.

Ground Insulation.

There are two types of ground insulation have been used in a process. First one is a technological layer of ceramic cloth for cable heat treatment. This cloth covered side plates of the reaction fixture and provided tiny channels for Argon flow purging coils. The second type is “0-shape”cloth of S-2 Fiberglass material covered only coils during epoxy impregnation step. After curing it forming one of two layers of designed G10 insulation (2x10mil).

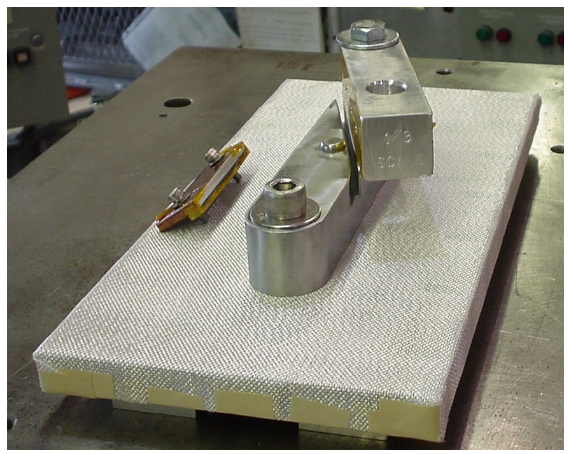
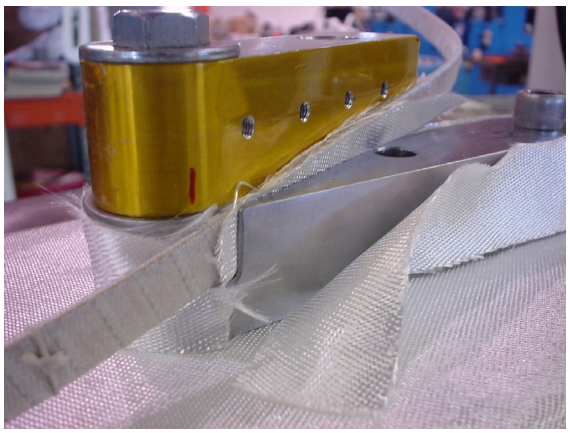


Figure 5. Winding plate (part of the reaction fixture) with ceramic insulation and a pole.

Winding Procedure

The insulated cable was re-spooled under 20lbs tension into two plastic reels, an inner cable reel with 23 feet (7 m) plus 10 feet of copper leader and an outer cable reel with 23 feet (7 m) plus 10 feet of leader. Starting from the middle point, the cable was pre-deformed around the pole piece to fit into layer jump grove without strands pop out. The pole was wrapped by ceramic cloth and the cable placed in a slot and held with a clamp. Than 40 lbs tension was applied to the cable and first turn has been wound.
Next 12 turns was wound with 60lbs tension.

Figure 6. Winding set up.



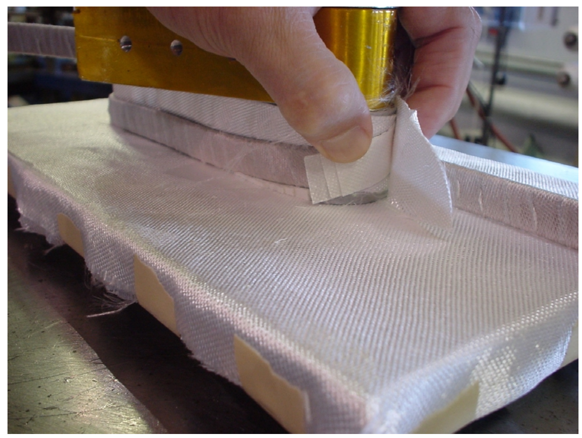
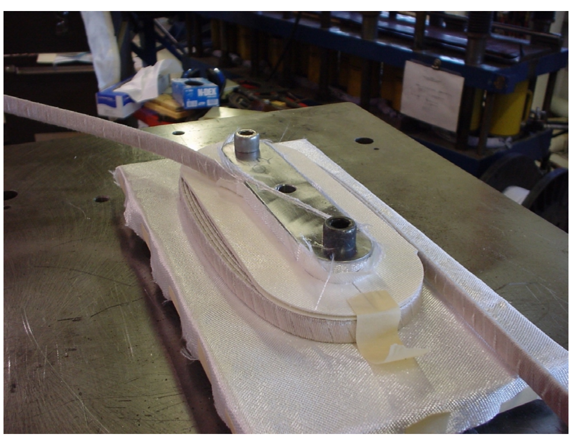


Figure 7. Cable sets into a layer jump groove
Figure 8. Cable insulated with ceramic cloth in pole groove.



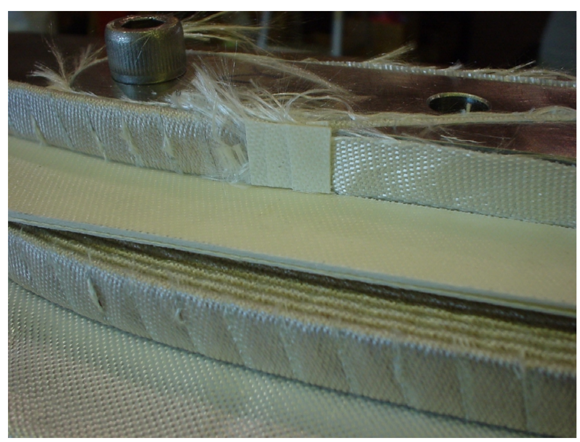
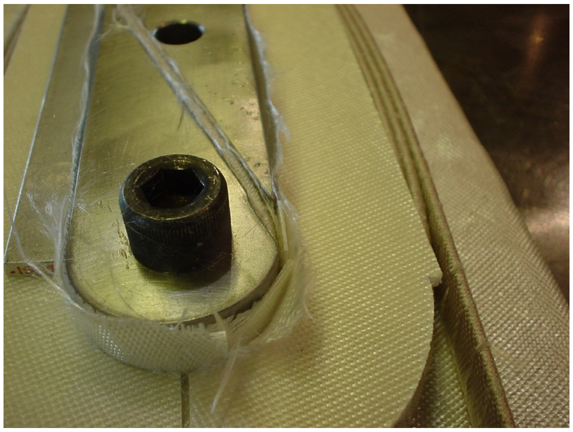


Figure 9. First layer completed.
Figure 10. An additional insulation fills voids around a layer jump groove. .



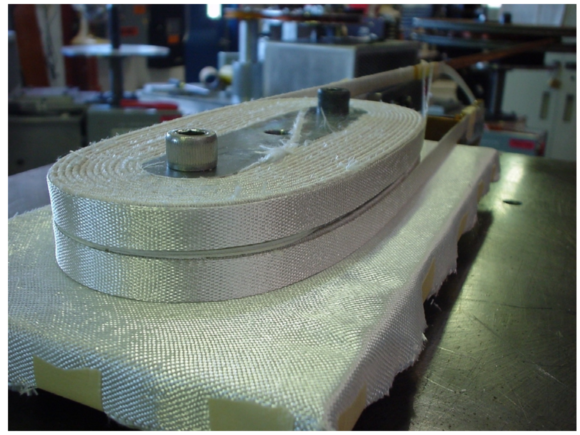


Figure 11. Interlayer spacers.
Figure 12. Completed winding.

The interlayer spacer was placed on top of the first wound layer (bottom coil). It consists of two "C"-shape 10-layers ceramic insulators, each 40mils ~1mm thick. They were cut from rectangular stacks of cloth cured at 150^{o}C for 30 min. These stacks were assembled together between two metal plates after the CTD binder was applied to each cloth layer. The installed spacers are shown in Fig 9-11.

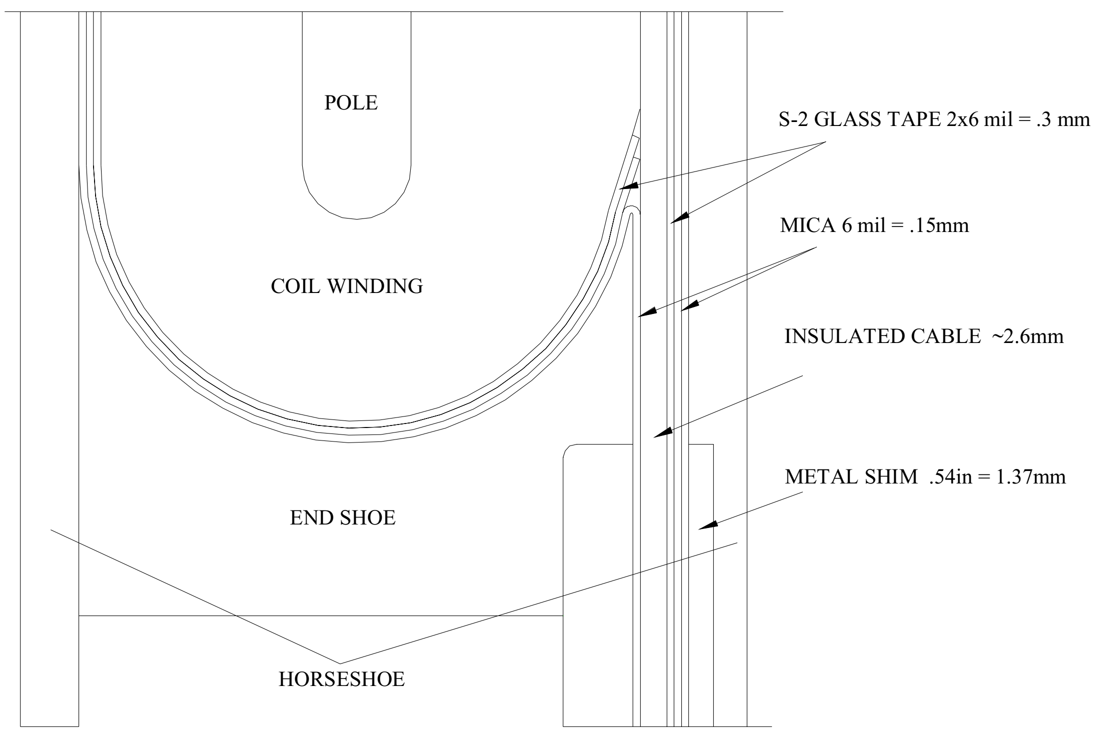
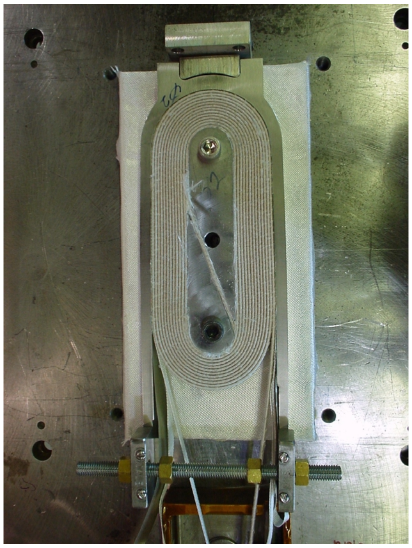


Figure 13. Coil shimming before reaction.



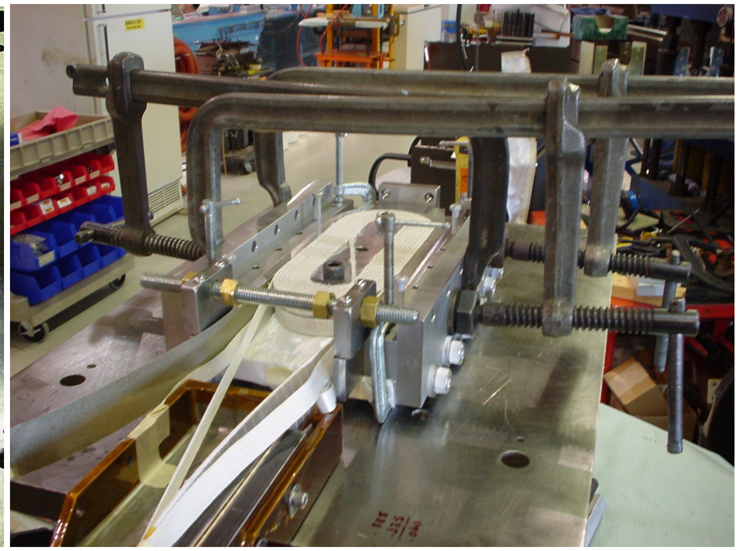
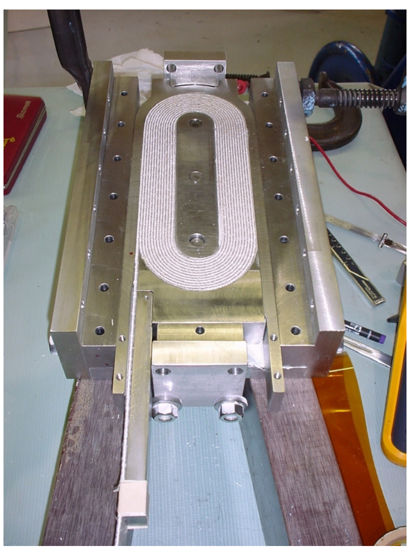


Figure 14,15. Horseshoe and side rails installation.



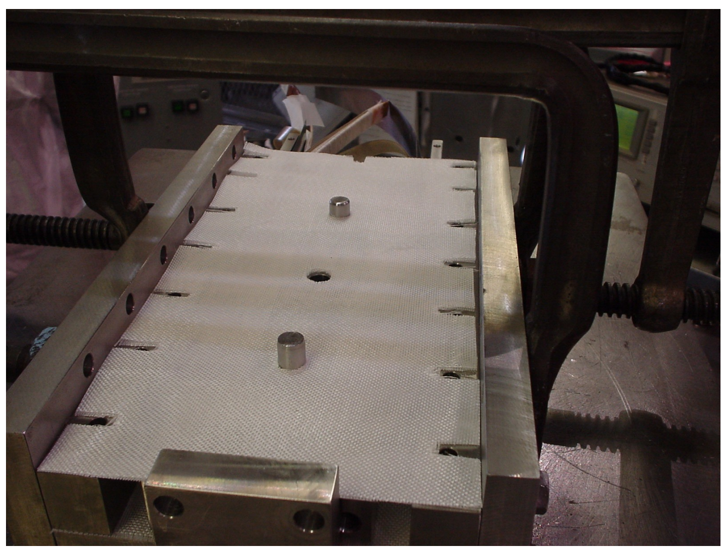
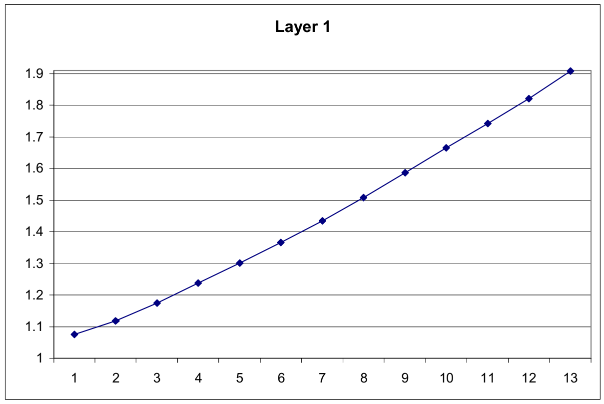
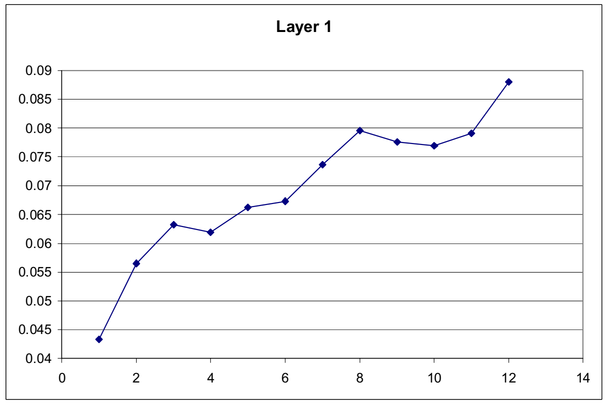


Figure 16. End shoe placement.
Figure 17. Ceramic ground insulation.

Turn-to-turn layer 1

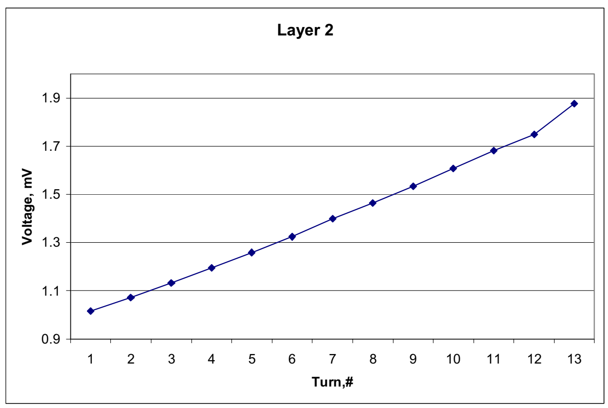
#	R	delta
1	1.0754	0
2	1.1187	0.0433
3	1.1752	0.0565
4	1.2384	0.0632
5	1.3003	0.0619
6	1.3665	0.0662
7	1.4338	0.0673
8	1.5075	0.0737
9	1.5871	0.0796
10	1.6647	0.0776
11	1.7416	0.0769
12	1.8207	0.0791
13	1.9087	0.088





Turn-to-turn layer 2

#	R	delta
1	1.0151	0
2	1.0731	0.058
3	1.1337	0.0606
4	1.195	0.0613
5	1.2591	0.0641
6	1.3238	0.0647
7	1.3991	0.0753
8	1.464	0.0649
9	1.5332	0.0692
10	1.6083	0.0751
11	1.6823	0.074
12	1.7489	0.0666
13	1.8763	0.1274



L	R	Q	F
21.502	1.8967	2.36	1kHz
27.001		0.08	20Hz

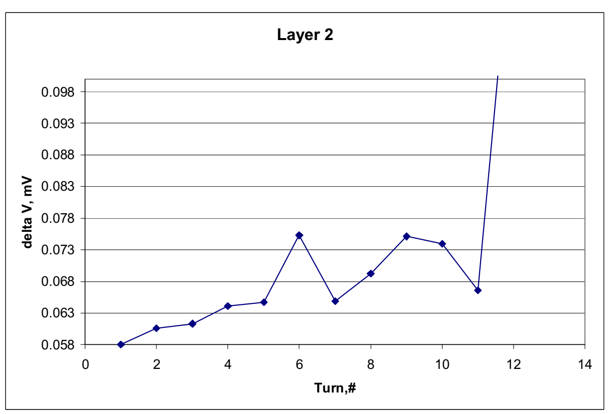


Figure 18. Turn-to-turn test after winding of #1 FNAL coil PIT cable 11-11-03

Coil Reaction

Coil heat treatment was performed in argon atmosphere at 655^oC. The reaction fixture and bunch of witness samples were placed inside a reaction retort as shown on Fig.19. Three thermocouples controlled a magnet and retort temperature.
After proper connections and top plate welding, the retort placed inside of the oven. The MJR coil heat treatment cycle was: 25^oC/h up to 210^oC and stay for 100 h, 50^oC/h up to 340^oC and stay for 48 h, 75^oC/h up to 660^oC and 72 h at 660^oC, down to 70^oC (see Fig 20).

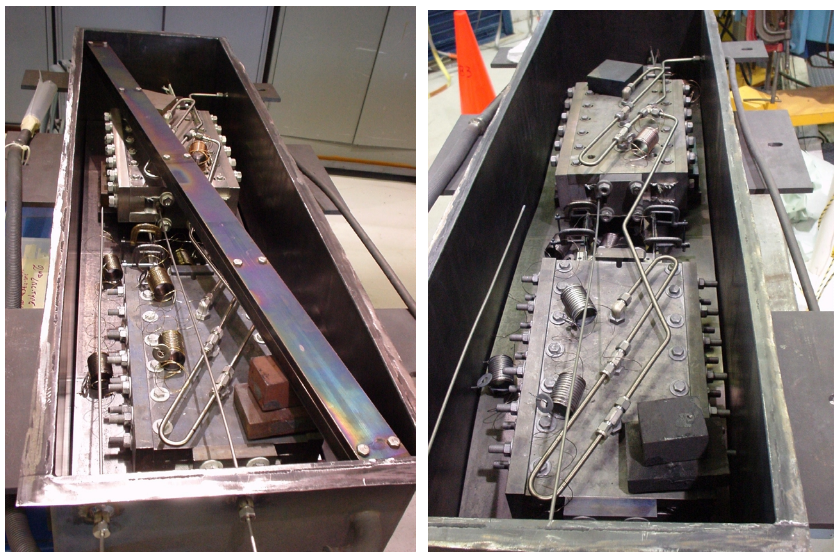


Figure 19a,b. Packed coils inside of the reaction retort.

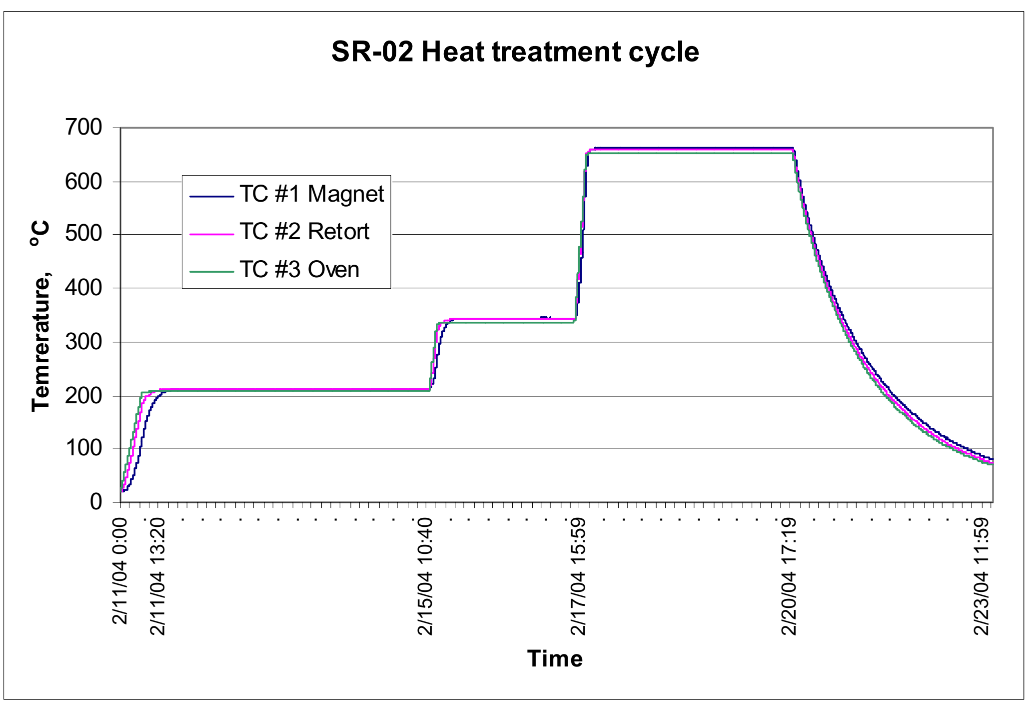


Figure 20. Reaction cycle for MJR conductor.

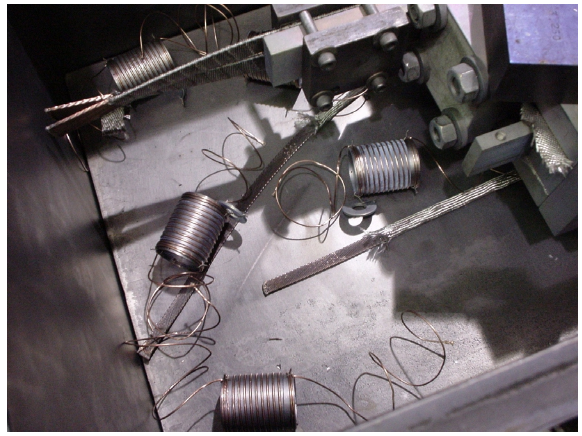
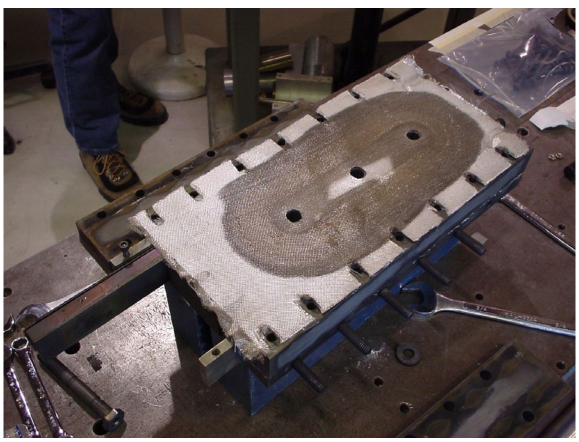


Figure 21. Reaction retort placed in the oven.
Figure 22. Strand barrels after heat treatment.

Post Reaction Procedure



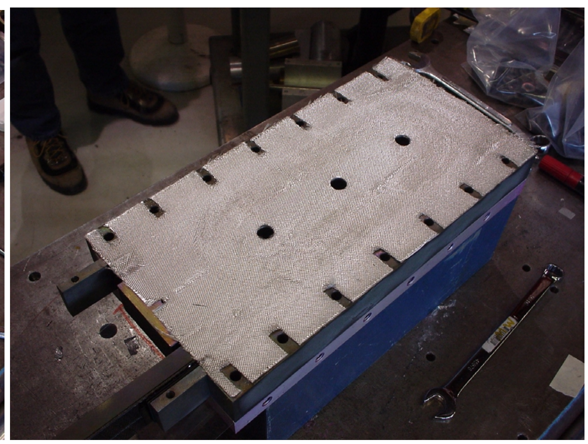
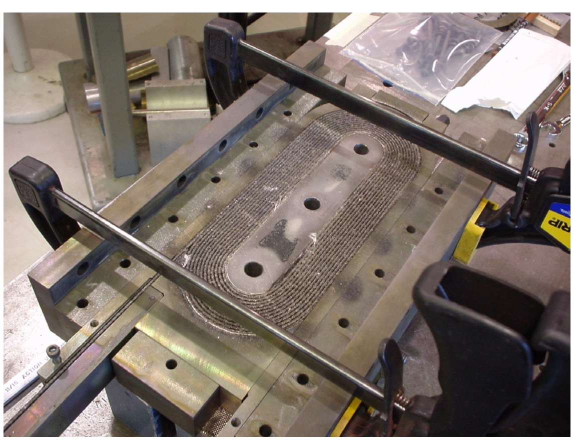


Figure 23,24. Reaction fixture and ceramic insulation after heat treatment.



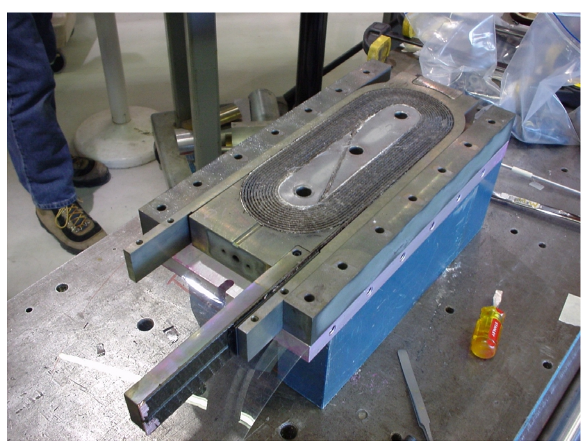
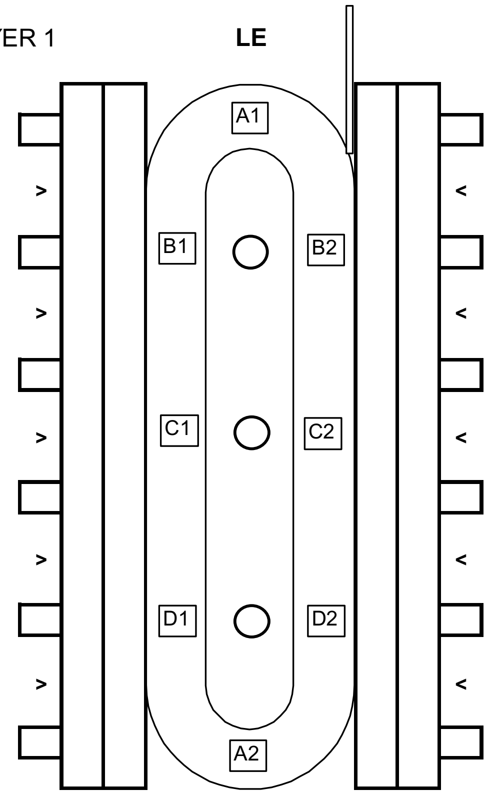


Figure 25,26. Visual inspection of the coil after reaction.

SUB-SCALE COILS BEFORE AND AFTER REACTION

MAG # **SR-02** DATE: INITIALS: **MW**

LAYER 1 **LE**



WIDTH, in

6.723

6.736

6.742

COIL WIDTH, mm

	Before	After
A1		32.64
A2		32.65
B1	32.26	32.04
B2	32.28	32.04
C1	32.08	31.99
C2	32.21	31.95
D1	32.05	32.00
D2	32.13	31.94

04/21/04

Notes:

Figure 27. Dimensions of coil winding before and after reaction.

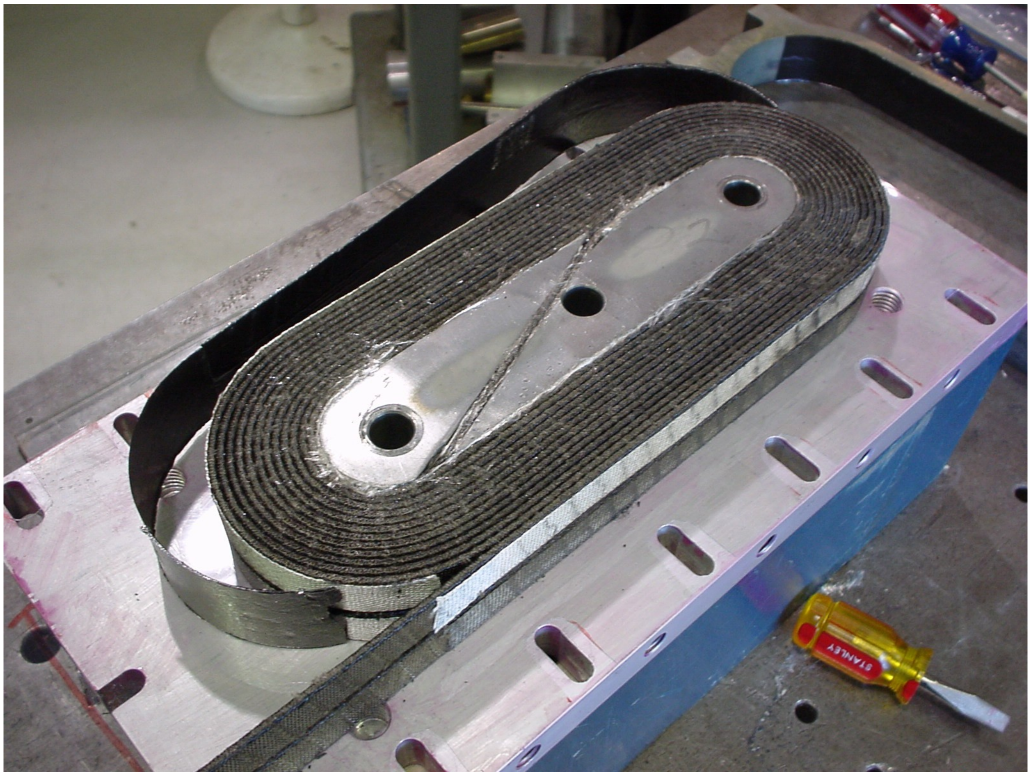


Figure 28. Removing the horseshoe and the metal shim.

Both leads spliced simultaneously. All six cables were properly shimmed and placed in a pre-adjusted fixture than six bolts hand tighten. The fixture was heated up to a tin melting point 220^{o}C and all bolts were further tightening till fixture gaps completely closed. Six Voltage Taps were attached to the cables and the splices insulated by Kapton tape 4x.002".

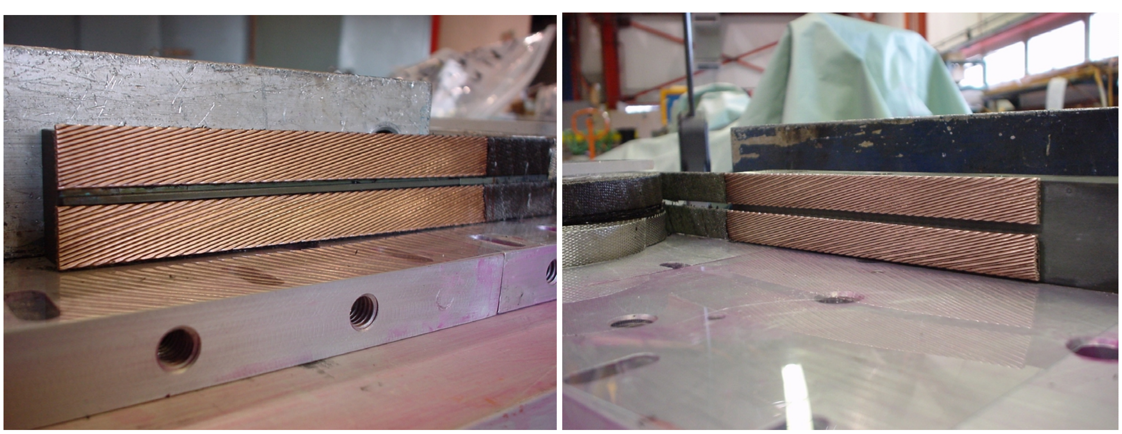


Figure 29,30. Clean Nb_3Sn leads and shimmed stack of the cables before splicing.

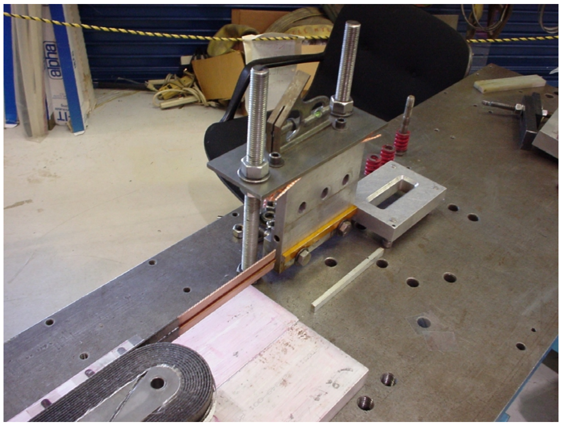
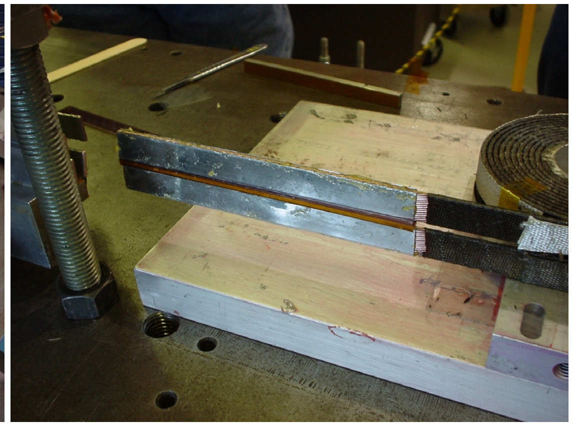
 

Figure 31,32. Splicing fixture and view of leads before splicing.

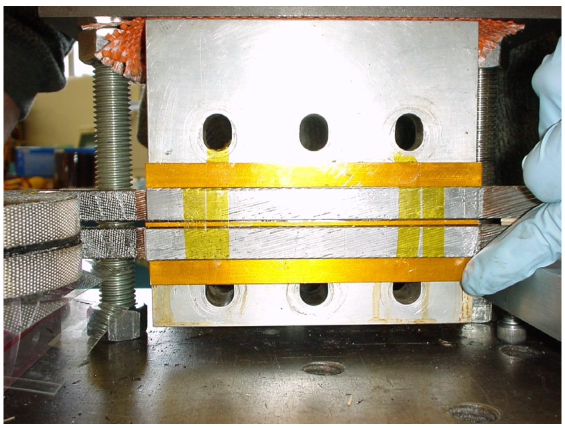
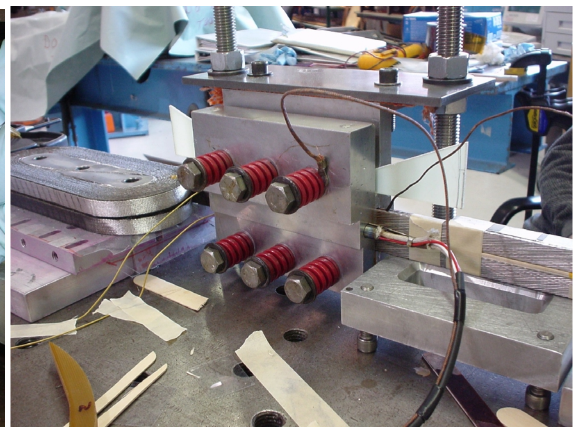
 

Figure 33,34. Splicing fixture.

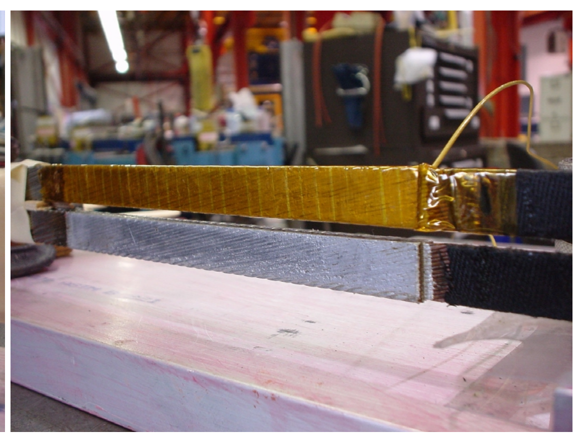
 

Figure 35,36. Spliced leads and lead after insulation by Kapton.

Splicing log

NbTi keystown cable — pretinned

	thickness	width
NbTi keystown cable	2.25	14.5
pretinned	2.4-2.68	14.6-15.0

.088x.078 — .089-.084

Nb_3Sn rectangular cable after reaction measured at the lead

thickness	width
2.0-2.2	14.3

.0786x.0796

by mic	#	1	2	3	avr	
top coil	thickness	0.0829	0.0804	0.0825	0.082	
	width	0.559	0.556	0.558	0.558	old
bottom coil	thickness	0.084	0.087	0.0837	0.085	
	width	0.559	0.559	0.558	0.559	old

Splice geometry

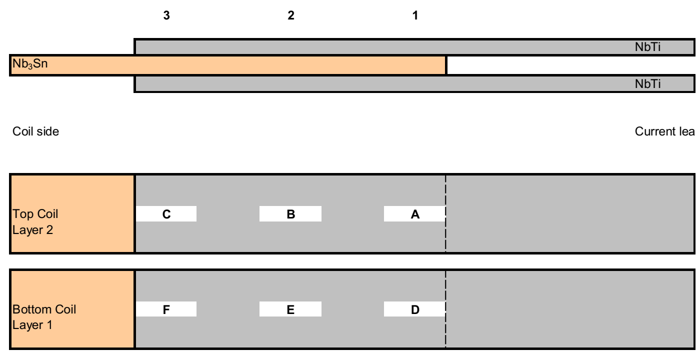


Figure 37. Measured cable dimensions.

Measurements: L=6in=152.5mm

Shim A

#	1	2	3	4	5	6	
original	0.281	0.28	0.281	0.281	0.28	0.28	
-0.02	0.257		0.258			0.257	modif.
0.003	0.26		0.261			0.26	add. 3mil Kapton

Shim C

#	1	2	3	4	5	6	
original	0.283	0.282	0.282	0.281	0.282	0.282	
-0.02	0.258		0.2575			0.257	modif.
0.003	0.261		0.2605			0.26	add. 3mil Kapton

Shim B

#	1	2	3	4	5	6	
original	0.284	0.285	0.285	0.285	0.284	0.282	
-0.02	0.2565		0.257			0.257	modif.
0.003	0.26		0.26			0.26	add. 3mil Kapton

Calculated Splice Thickness

Shim	NbTi cable	Nb_3Sn cable	NbTi cable	Solder x 2	delta	
0.261	0.089	0.082	0.078	0.012	0	top
0.261	0.089	0.085	0.078	0.009	0	bottom

Final Measurements of the complited Splices

by mic	#	1	2	3	avr	predicted	delta	solder x 2
top coil	thickness	0.2641	0.2647	0.264	**0.264**	0.261	-0.003	0.015
	width							
bottom coil	thickness	0.2628	0.265	0.262	**0.263**	0.261	-0.002	0.011
	width							

Insulated Splice Thickness

Insulation: 4x1.3=5.2 mil Kapton w polyimid

by mic	#	1	2	3	avr
top coil	thickness	0.2693	0.2682	0.2673	**0.268**
bottom coil	thickness	0.2685	0.2676	0.267	**0.268**

Splicing fixture setup

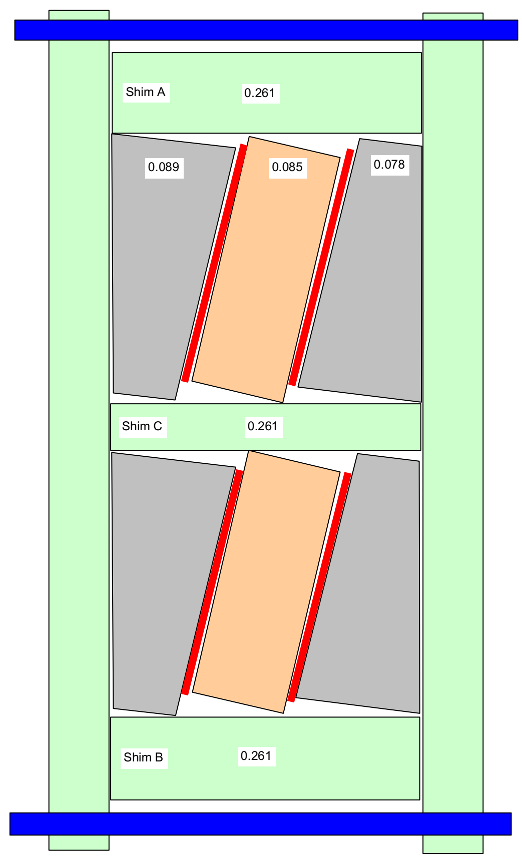


Figure 38. Splicing fixture parameters and final splice size.

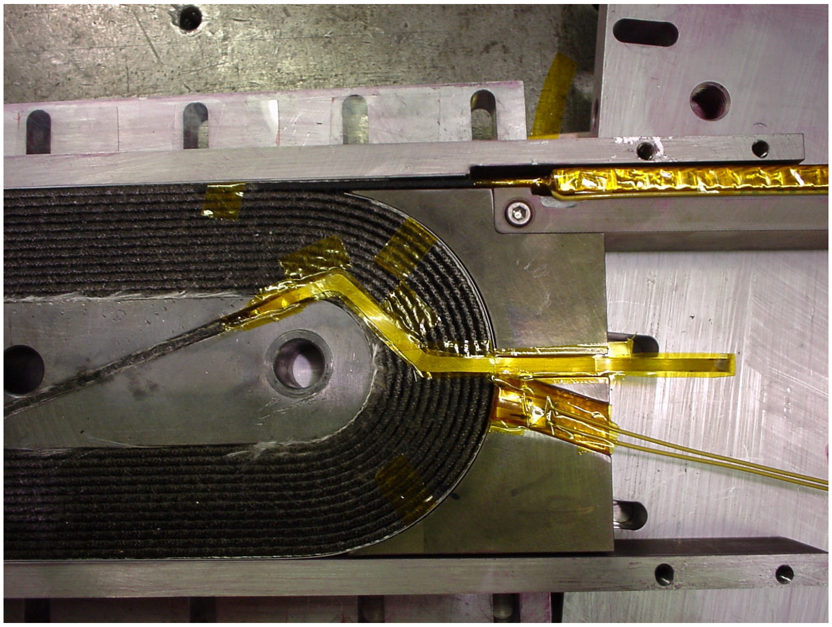


Figure 39. End shoe with insulated Spot Heater.

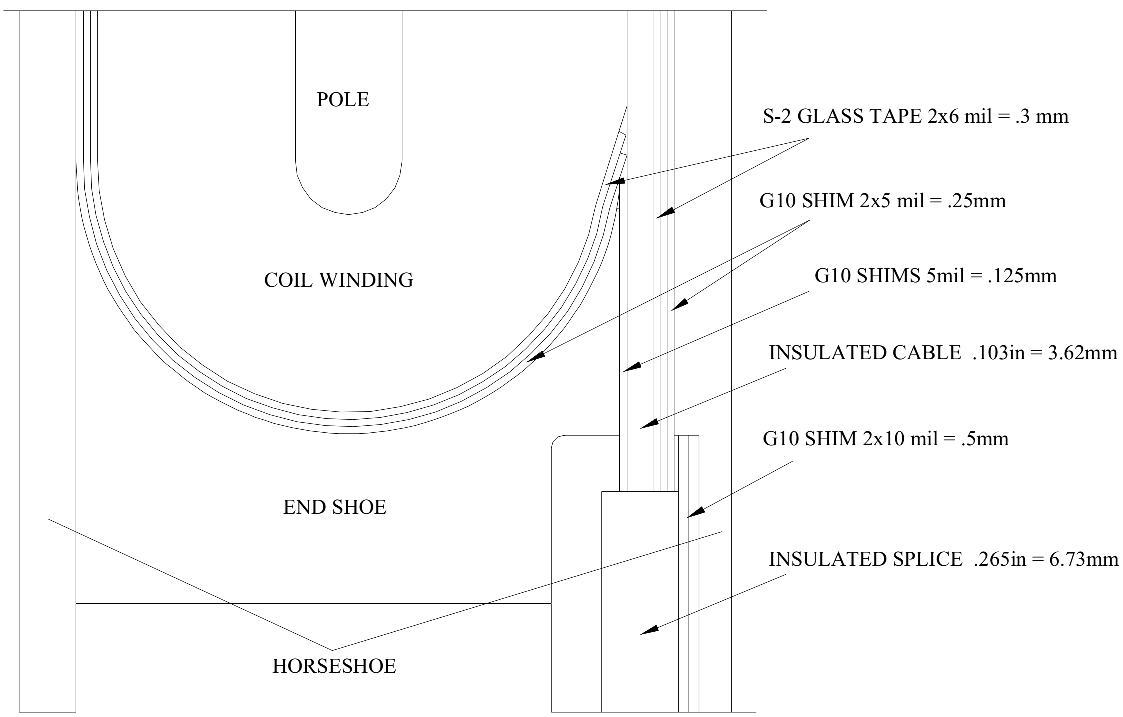


Figure 40. Coil shimming before impregnation.

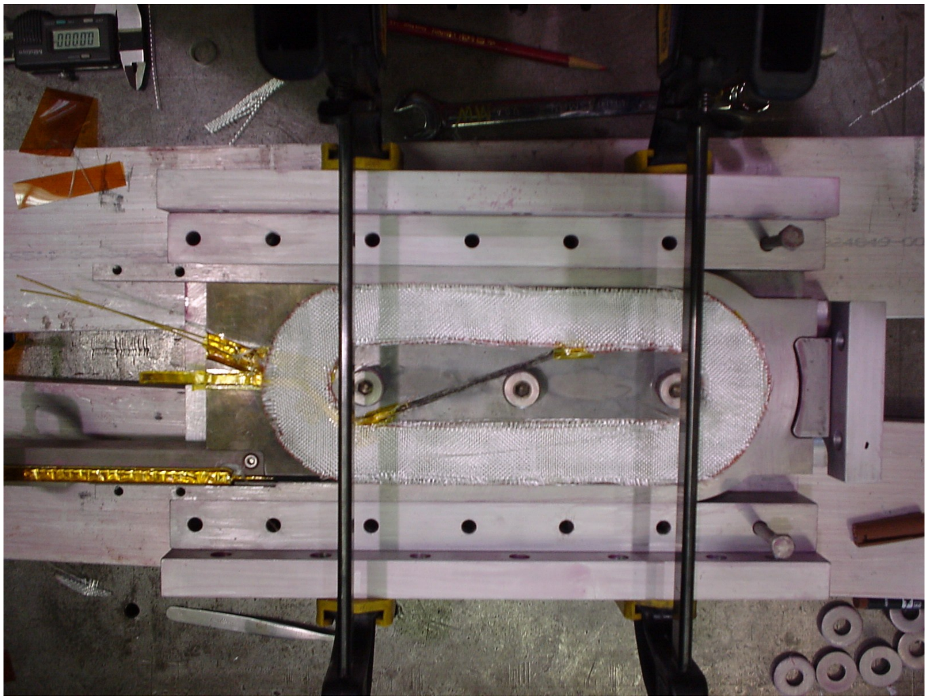


Figure 41. Horseshoe and side bar installation over the coil.

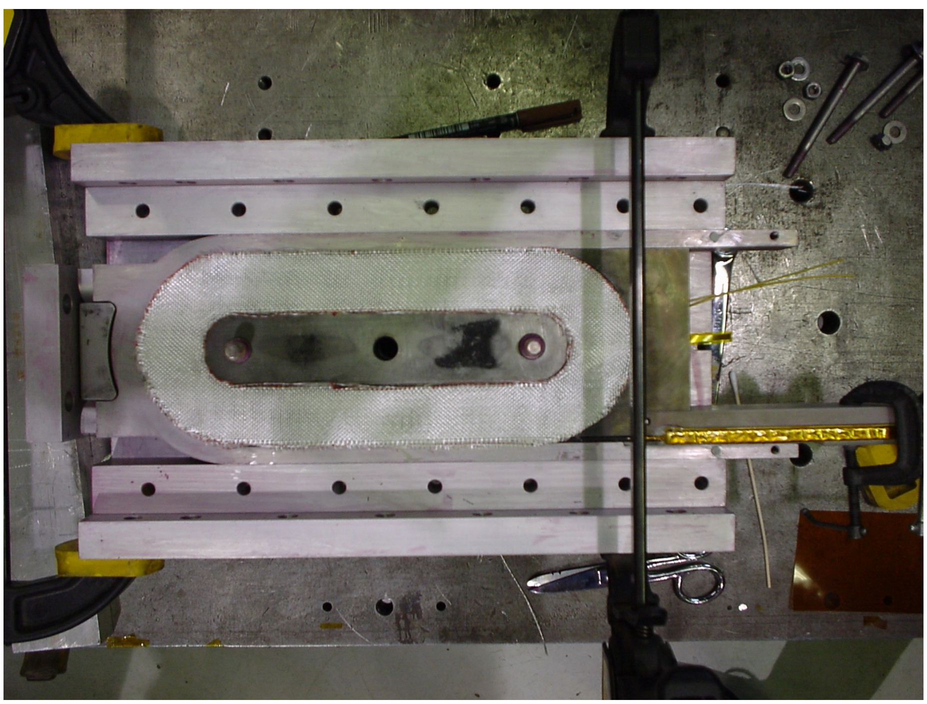
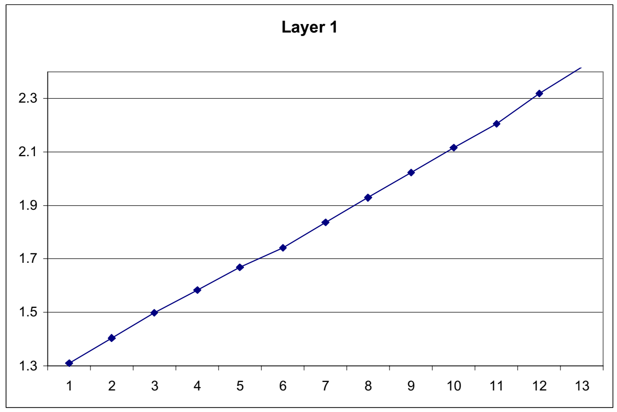


Figure 42. S-2 glass coil ground insulation.

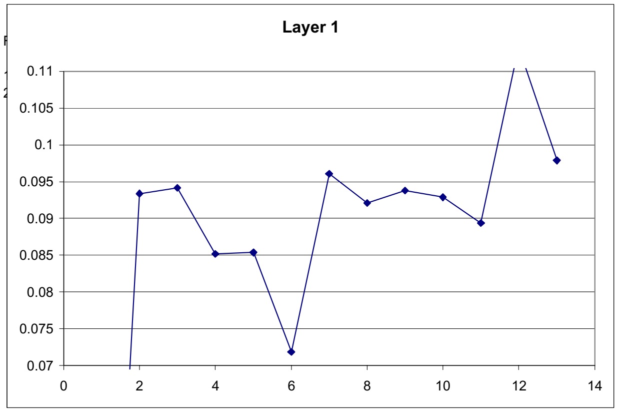
Turn-to-turn layer 1

#	R	delta
1	1.3106	0
2	1.404	0.0934
3	1.4982	0.0942
4	1.5834	0.0852
5	1.6688	0.0854
6	1.7407	0.0719
7	1.8368	0.0961
8	1.9289	0.0921
9	2.0227	0.0938
10	2.1156	0.0929
11	2.205	0.0894
12	2.3183	0.1133
13	2.4162	0.0979



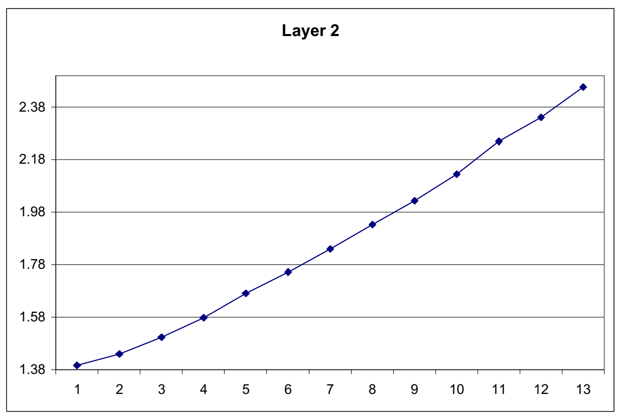
3/25/2004

L	R	Q
	2.584	
	2.5326	



Turn-to-turn layer 2

#	V[mV]	delta
1	1.3956	0
2	1.4397	0.0441
3	1.504	0.0643
4	1.5773	0.0733
5	1.6709	0.0936
6	1.7519	0.081
7	1.8397	0.0878
8	1.933	0.0933
9	2.0232	0.0902
10	2.1253	0.1021
11	2.2499	0.1246
12	2.3415	0.0916
13	2.4558	0.1143



one plate removed, using c-clamp for pusher bars holding

3/22/2004

L	R	Q	F
16.834	2.3076	1.74	1kHz
26.4714		0.14	20Hz

3/25/2004

L	R	Q	F
16.18	2.5463	1.8	1kHz
25.75	2.5642	0.13	20Hz

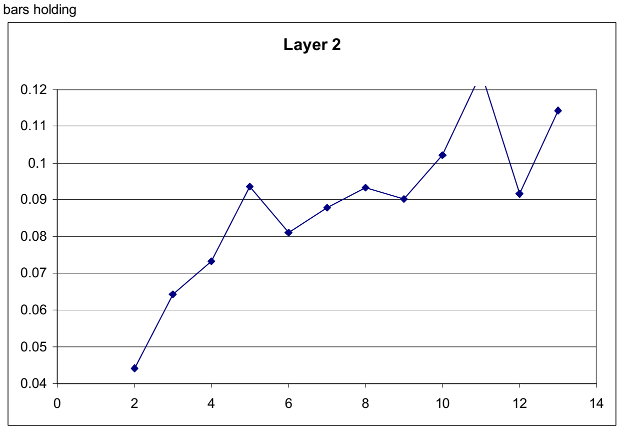


Figure 43. Electrical test before impregnation of #2 FNAL coil, MJR cable 3-25-04

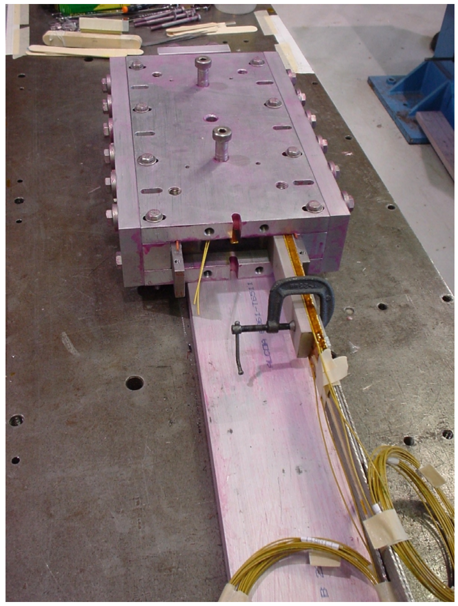


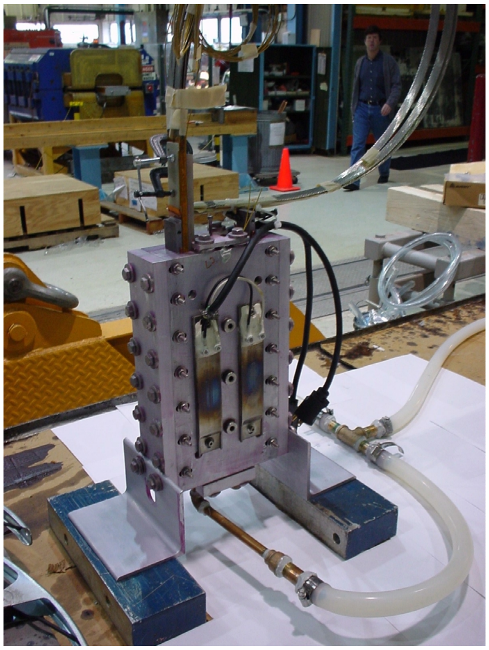
Figure 44. Impregnation fixture with cable support around splice area.

Coil epoxy impregnation

The fixture has been pumped out in IB2 vacuum oven for 48 h.

Material Designation Parts by weight:
Resin Part A 7.5 Kg
Hardener Part B 6.75 Kg
Accelerator Part C 112.2 g

Start epoxy mixing	8:45 a.m.	
Start heating	8:55 a.m.	T=30C-40C-45C-60C
Start out gassing	9:20 a.m.	
Stop	10:00 a.m.	
Vacuum = 45 microns		
Vacuum at tank = -30psi		
Start flow to bucket	10:05 a.m.	
Start flow to magnet	10:15 a.m.	
Flow rate 0.5 cm per sec		
Vacuum at the vessel **19** micron		
Epoxy at top of the fixture	11:00 p.m.	
Stop epoxy flow	11:30 p.m.	
Shut off vacuum	11:45 a.m.	
Maintained 55C heat to coil		
Start cure cycle	2:00 p.m. 3-30-04,125C for 21 hrs	
Finish cure cycle	11:00 a.m. (next day)	



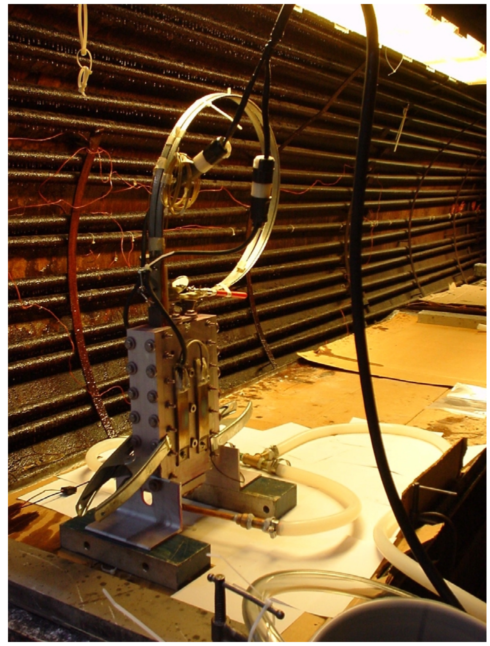


Figure 45,46. Assembled impregnation fixture and fixture connections inside a vacuum oven in IB2.

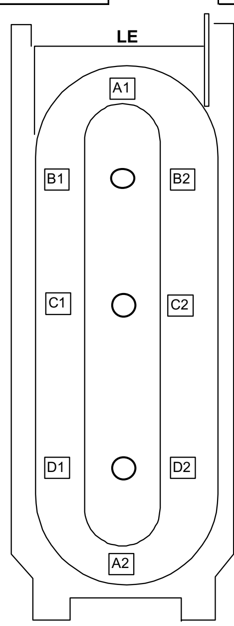
Coil Block Shimming

To prevent brittle coil conductor from over compression, a thickness of the pole island, the coil, the end shoe and the horseshoe should be the same. We control these dimensions by micrometer at six locations. Than the coil and the horseshoe was properly shimmed with Kapton.

SUB-SCALE COILS BEFORE AND AFTER SHIMMING

MAG # **SR-02** DATE: 4/14/2004 INITIALS: AL

LAYER 1



THICKNESS, in

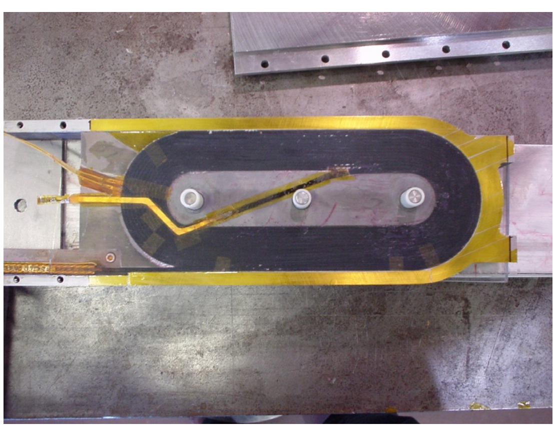
	Before			After		
	coil	horseshoe	pole	coil	horseshoe	pole
A1	1.261			1.261		1.266
A2	1.261	1.275		1.261	1.275	
B1	1.261	1.258	1.266	1.261	1.258	1.263
B2	1.261	1.259		1.261	1.259	
C1	1.261	1.258	1.266	1.261	1.258	1.264
C2	1.261	1.259		1.261	1.259	
D1	1.261	1.259	1.266	1.261	1.259	1.264
D2	1.261	1.260		1.261	1.260	

~2-3 mil of epoxy was removed fron one side of the island (layer 1)

Figure 47. Size of the coil block before and after shimming.

To check a pressure distribution coming from 12-pressure pad bolts a Fuji film test was performed on the coil block.
Result shown on Fig.48 (max pressure 10-12MPa.).

Figure 48. Result of Fuji film test.



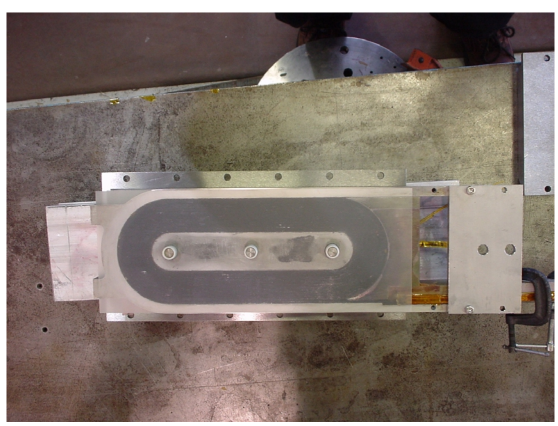


Figure 49. Coil after shimming.
Figure 50. A G10 ground insulation.

Cylinder-Yoke Pre-assembly

Cylinder-yoke pre-assembly is a part of final assembly procedure. It allows bladder and instrumentation checking. Technological shim sizing, shim installation and removing can be tested as well. After this step, shimmed yoke will load the aluminum cylinder and a coil cavity will be big enough for coil block insertion.

Set up overview is shown on Fig. 51. A metal brick substituted the coil for this step. Only one bladder pressurized a structure from inside till 77mil thick metal strips were inserted between two yokes.

Final measurements of coil cavity are shown on Fig. 52. Eight resistive strain gauges glued to the cylinder and monitored stress level. All gauge data summarized in Fig. 61.

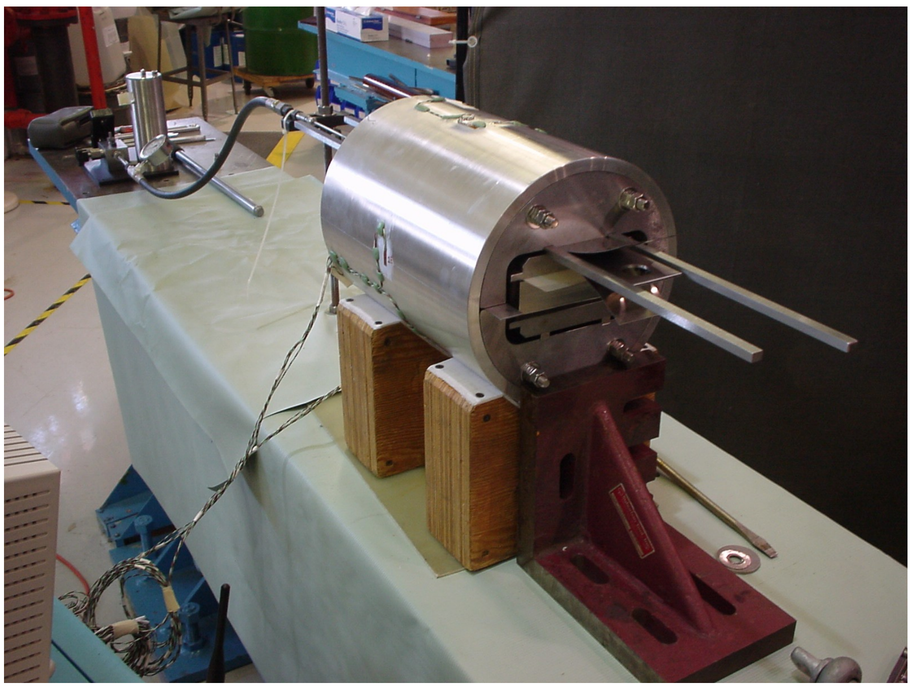
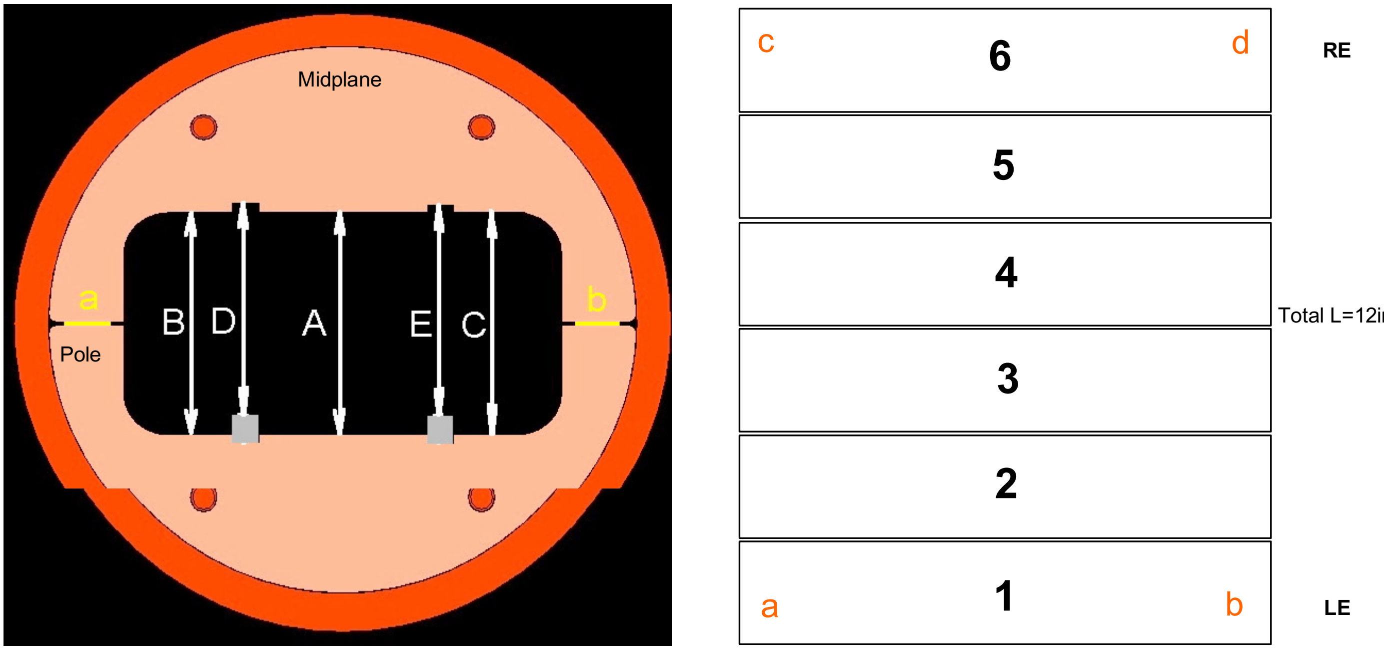


Figure 51. A mechanical model used for cylinder yoke pre-assembly.

Cylinder-Yoke Pre-assembly



All nimbers in inch

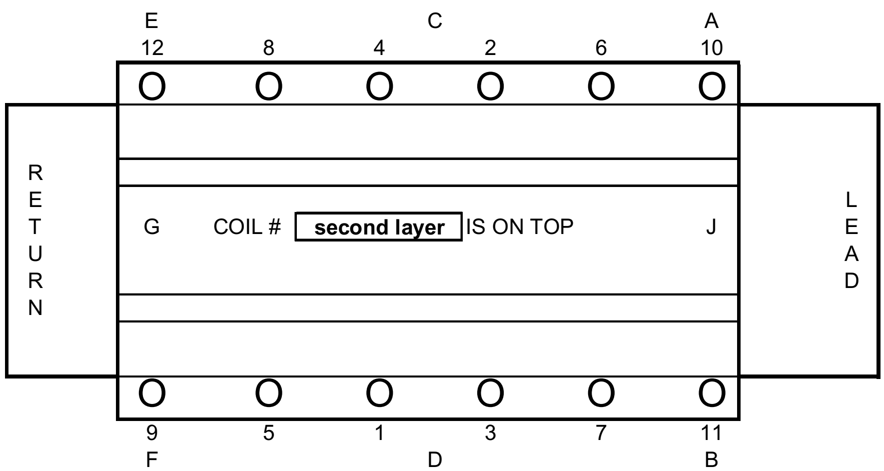
#	1	2	3	4	5	6	min	max	delta
A	3.422	3.421	3.42	3.421	3.42	3.421	3.42	3.422	0.002
B	3.422	3.423	3.42	3.421	3.42	3.421	3.42	3.423	0.003
C	3.423	3.422	3.42	3.422	3.421	3.42	3.42	3.423	0.003
D	3.324	3.329	3.327	3.325	3.326	3.326	3.324	3.329	0.005
E	3.327	3.327	3.321	3.32	3.322	3.326	3.32	3.327	0.007
a	0.0725								
b	0.074								

Gap A	3.42-3.055=0.365	:2	=	0.182		
		-key			"+delta"	one-side shim
Gap D	3.324-3.001=0.323	-0.296	=	0.027	0.005	**0.0166**
Gap E	3.324-3.00=0.324	-0.296	=	0.028	0.007	**0.017**

Figure 52. Cavity size measurements after cylinder-yoke pre-assembly.

SUB-SCALE PACKAGE ASSEMBLY SEQUENCE

MAG # **SR-02-MJR** DATE: INITIALS: **AL**



Torque in inch pounds

	Base	24 inch lbs	48 inch lbs	72 inch lbs	96 inch lbs	groove
A	3.063	3.058	3.056	3.055	3.054	3.002
B	3.067	3.057	3.057	3.055	3.055	3.003
C	3.061	3.06	3.057	3.055	3.054	3.002
D	3.061	3.061	3.057	3.054	3.054	3.000
E	3.06	3.059	3.056	3.053	3.052	3.000
F	3.064	3.06	3.056	3.055	3.053	3.000
J	3.065	3.061	3.058	3.055	3.056	
G	3.059	3.056	3.055	3.054	3.054	

A-F is the measurement at the indicated positions of the coil package thickness.

Figure 53. Sequence of coil block assembly.

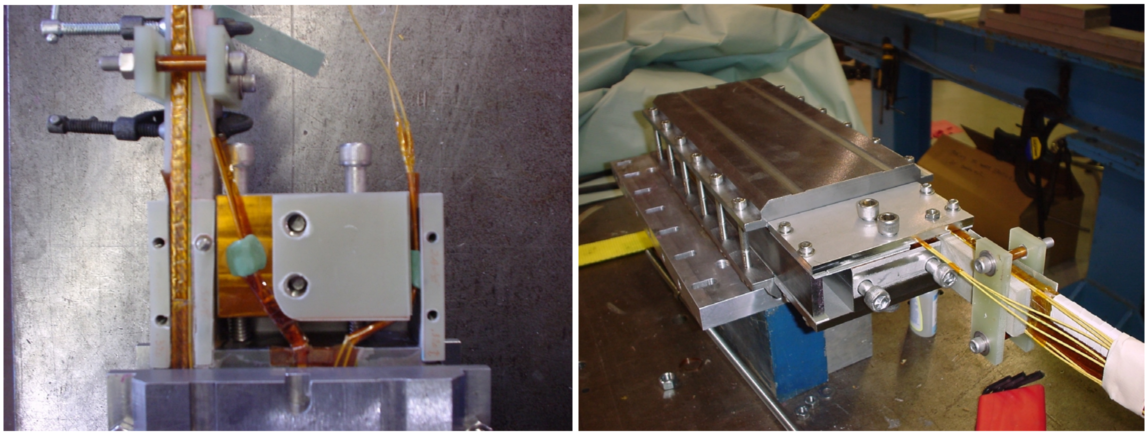
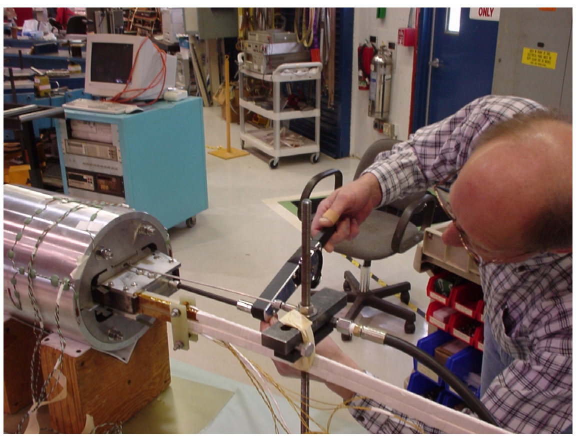


Figure 54,55. Assembled coil block.



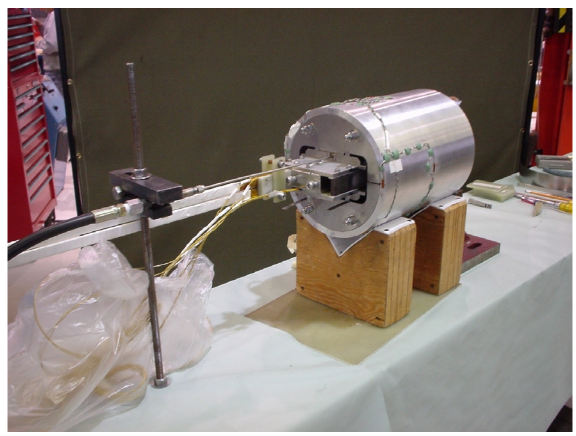
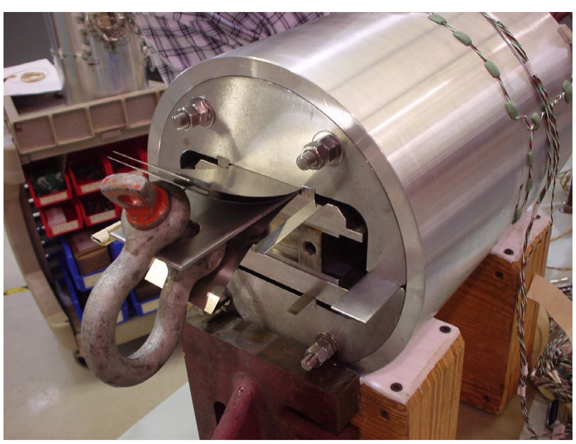


Figure 56. Torque the 4 axial tension bolts to 12 inch lbs.
Figure 57. Final loading.



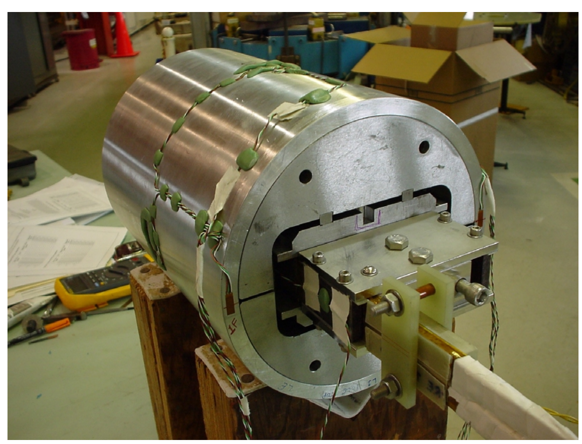


Figure 58. Bladder protection shims.
Figure 59. Model view after assembly.

Strain Gauges

Total eight resistive strain gauges install in the aluminum cylinder. Six of them located at the middle of the magnet. There are 4 azimuthal: 2A-a, 2B-a, 2D-a, 2E-a and 2 longitudinal: 2G-l, 2H-l gauges. 2A-a and 2D-a named as midplane-azimuthal gauges and 2B-a and 2E-a as pole-azimuthal gauges with 90^{o} difference in location on the cylinder. Gauges 2C and 2F located on the edge and measured average stress across cylinder thickness.

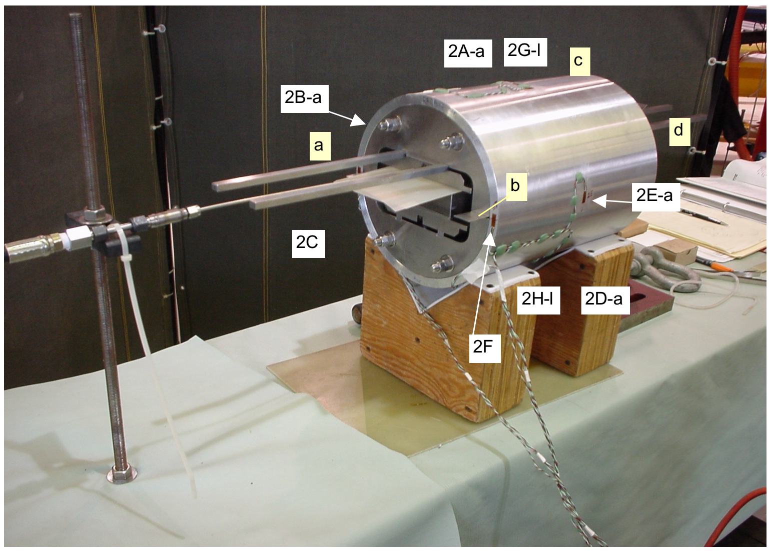


Figure 60. Strain gauges location on the cylinder.

Gauge's data for two assembly steps: cylinder-yoke pre-assembly and final assembly step are plotted on Fig. 61. Gauges 2A-a and 2D-a were chosen as main process indicators since they are located in the area of uniform cylinder stretching. The maximum reached load was 120 MPa. Spring back for the keying process is in a range of 25-30%.

All gauge parameters and a final reading listed in Table 2. We also monitor an OD change for aluminum cylinder measured with Pi-tape and by micrometer. These data plotted on Fig. 62.

Strain Gauges on the AL Skin of the SR-02 MJR FNAL

#	Strain Gage Type		IB3 name	VMTF name	Gage Factor	Rzero	R(Fully-Loaded)-300K(IB3_final)	R(Fully-Loaded) 4-wire check out
1	WK-13-250BG-350	Skin Gauges Azimuthal	2A-a	SG_1	2.07	350.039	351.019	351.12
2	WK-13-250BG-350	Skin Gauges Azimuthal	2B-a	SG_2	2.07	349.97	349.553	349.605
3	WK-13-250BG-350	Skin Gauges Cross-Section	2C	SG_7	2.07	349.734	350.468	350.517
4	WK-13-250BG-350	Skin Gauges Longitudinal	2G-l	SG_5	2.07	349.935	349.759	349.789
5	WK-13-250BG-350	Skin Gauges Azimuthal	2D-a	SG_3	2.07	350.003	351.059	351.142
6	WK-13-250BG-350	Skin Gauges Azimuthal	2E-a	SG_4	2.07	350.124	349.711	349.765
7	WK-13-250BG-350	Skin Gauges Cross-Section	2F	SG_8	2.07	349.872	350.763	350.839
8	WK-13-250BG-350	Skin Gauges Longitudinal	2H-l	SG_6	2.07	350.21	350.07	350.087
9	WK-13-250BG-350	Main Compensator	2I-comp	SGC	2.07	349.703	349.704	349.76

Table 2. Final data of strain gauges.

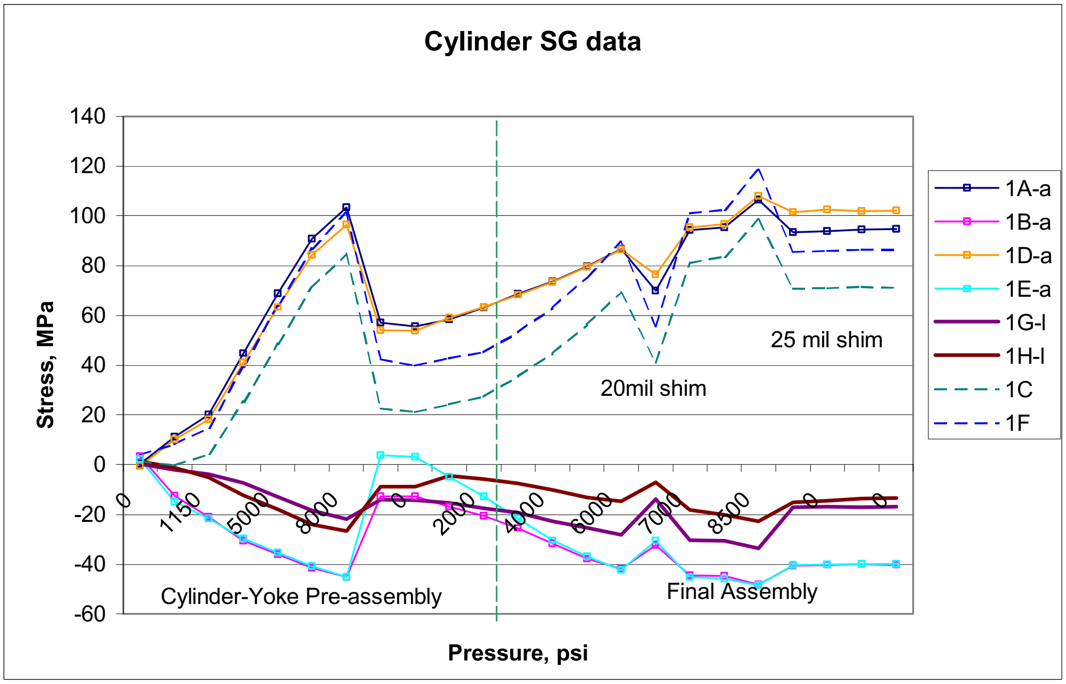


Figure 61. Strain gauges history.

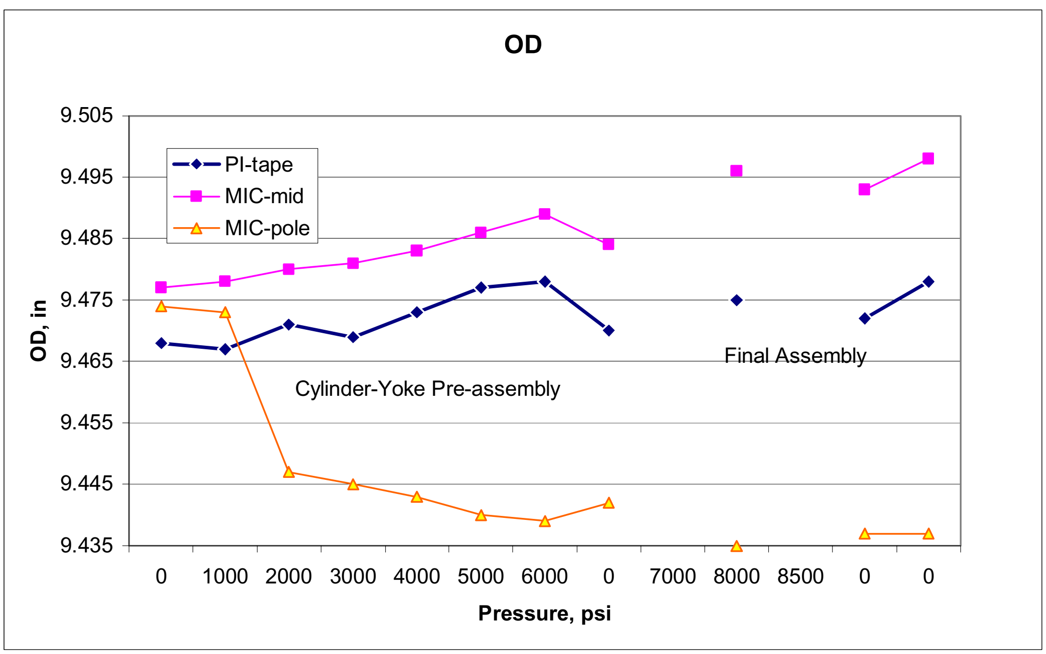


Figure 62. Cylinder's OD changing.

Electrical parameters

All electrical readings for coil L, R, Q at different production steps are listed below:

Electrical test after winding of #2 FNAL coil MJR cable 10-23-03

L	R	Q	F
uH	mV/.1A		
21.502	1.8967	2.36	1kHz
27.001		0.08	20Hz

Electrical test after reaction of #2 FNAL coil MJR cable 3/25/04

one plate removed, using c-clamp for pusher bars holding

L	R	Q	F
uH	mV/.1A		
16.18	2.5463	1.8	1kHz
25.75	2.5642	0.13	20Hz

Electrical test before impregnation of #2 FNAL coil MJR cable 3/26/04

L	R	Q	F
uH	mV/.1A		
11.395	2.3596	1.41	1kHz
24.475		0.13	20Hz

Electrical test after impregnation of #2 FNAL coil MJR cable 4/12/04

L	R	Q	F
uH	mV/.1A		
11.494	2.3956	1.42	1kHz
26.136		0.13	20Hz

Electrical test before yoking on bench assembled FNAL coil, MJR cable 4/14/04

L	R	Q	F
uH	mV/.1A		
18.0407	2.3918	1.49	1kHz
37.2034		0.19	20Hz

Electrical test after removing bladders of FNAL coil, MJR cable 4/16/04

L	R	Q	F
uH	mV/.1A		
18.334	2.445	1.51	1kHz
37.892		0.2	20Hz

Voltage Taps

Total 13 VT were attached to the coil. VT connection scheme is shown on figure below. All taps were attached to hypetronics according to document "VMTF Test Stand Magnet/DAQ System Interface. Magnet: SR02"

SR-02 "Small Racetrack Magnet-MJR "

Position of all voltage taps

#/position	Name/VMTF	Δl*	Total*	Rforward	Dead/Alive	Location	Purpose	Twisted
1	**BLRS1**	0	0		active	on the splice-NbTi cable lead-side	Quench Coil Lead Protection	
2	**BLRS2**	0.152	0.152		active	on the splice-NbSn cable coil-side	Quench Coil Lead Protection	
3	**BLp**	0	0.152		active	on the splice-NbSn cable coil-side	Quench Current Lead Protection	along the NbTi lead
4	**BSp**	0	0.152		active	on the splice-NbSn cable coil-side	Spike Recording System	
5	**BCF**	0	0.152		active	on the splice-NbSn cable coil-side	Quench Detection System	
6	**BCSp**	6.848	7		active	middle point	Spike Recording System	
7	**CF**	0	7		active	middle point	Quench Detection System	
8	**TCSp**	0	7		active	middle point	Spike Recording System	
9	**TCF**	6.848	13.848		active	on the splice-NbSn cable coil-side	Quench Detection System	
10	**TSp**	0	13.848		active	on the splice-NbSn cable coil-side	Spike Recording System	
11	**TLp**	0	13.848		active	on the splice-NbSn cable coil-side	Quench Current Lead Protection	along the NbTi lead
12	**TLRS2**	0	13.848		active	on the splice-NbSn cable coil-side	Quench Coil Lead Protection	
13	**TLRS1**	0.152	14		active	on the splice-NbTi cable lead-side	Quench Coil Lead Protection	

* estimation

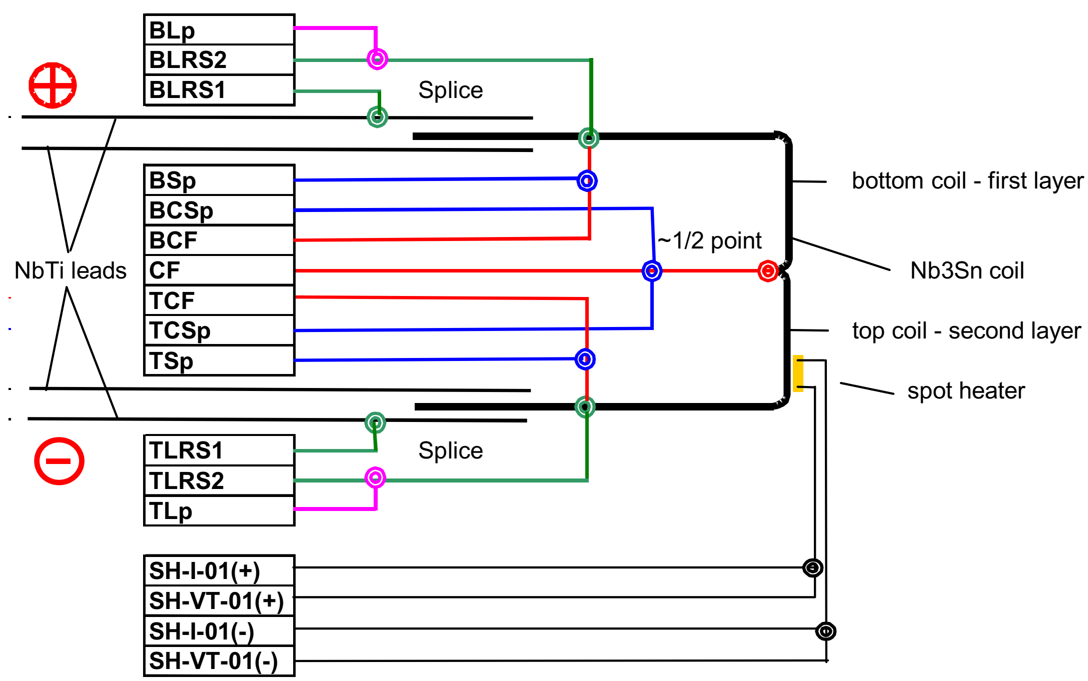


Figure 63. Summary of VT's and Spot Heater's reading and Hi-pot test data.

Final Electrical Reading

Table 3. SR-01final test.

Electrical test final before ship to VMTF of #2 FNAL coil MJR cable

4/27/2004

	R		L	Q	F
	mV/.1A		uH		
R-start	**2.4063**		**18.6434**	**1.53**	1kHz
R-finish	**2.4018**		**38.3384**	**0.2**	20Hz

VT reading at IB3

IB3	(+) to tap	(-) to tap
BLRS1	**8.9826**	**238.0316**
BLRS2	**9.7621**	**237.2397**
BLp	**9.7548**	**237.1404**
BSp	**9.7409**	**237.1346**
BCF		**237.1409**
BCSp	**125.3373**	**121.5464**
CF		**121.5304**
TCSp	**125.3166**	**121.5521**
TCF		**6.7028**
TSp	**240.1948**	**6.707**
TLp	**240.1769**	**6.7074**
TLRS2	**240.1597**	**6.7044**
TLRS1	**240.8527**	**5.9957**
Spot Heater		**3.3553 ohm**

Hi-Pot test	**V**		uA
coil-to-ground	**1000V**	**<0.5 uA**	0.004
SH-to coil	**1000V**	**<0.5 uA**	0.002
SH-to-ground	**1000V**	**<0.5 uA**	0.002